charges of electricity through gases. A discharge of electricity in the shape of a flame three feet high can be obtained by connecting the ends of the battery and suddenly separating them, and it is highly dangerous to touch the terminals of the battery, since the voltage or electrical pressure amounts to 20,000 volts. This pressure can be exalted almost to any extent. I have used from 300,000 to 500,000 volts.

With this battery I have ascertained that it requires about 100,000 volts to produce the Roentgen rays, and the energy required amounts to about 3,000,000 horse power acting for one-millionth of a second. The duration of this exhibition of energy is exceedingly short and, therefore, the work if spread over a second would seem very small. Nevertheless, we perceive that the shock given to the molecules of matter must be extremely powerful; and we can understand why the Roentgen rays can pass through blocks of wood more than a foot thick, can penetrate human flesh, and can blacken photographic plates in dark rooms at least sixty feet away from the little Crooke's tubes in which the rays are generated.

The most interesting fact, however, which I have discovered is this: When the Roentgen rays are being developed with the greatest intensity, the discharge of electricity encounters very little resistance in passing through the attenuated space inside the Crooke's tubes. It has been believed hitherto that a vacuum can not conduct electricity. My experiments, however, lead me to conclude that under certain conditions it can be made to conduct, and that it offers hardly any resistance to a disruptive discharge of electricity. When the discharge is started it appears to go with the greatest ease. This fact leads to interesting suppositions in regard to the structure of the ether of space. The discovery of the Roentgen rays has given a great impulse to the subject of the discharge of electricity through gases, and the Jefferson Physical Laboratory has now important means and methods of studying the great problem of the mechanism of this discharge of electricity in rarefied media.

ON THE MECHANICS OF THE KITE.[1]

By HORACE M. DECKER, B. S., Irvington, Essex Co., N. J. (dated December, 1896).

The kite as a motor for ascension depends on the dynamic effects of the impulse of wind on plane surfaces.

The pressure of wind on a plane surface at right angles to the direction of motion is given by the well-known equation

$$P = k\,a\,w\,h, \tag{1}$$

which measures the inertia of the column of fluid encountered. a is the area of the plane in square feet; w is the weight of a cubic foot of air which may be taken in ordinary as 0.08 pound avoirdupois; $h = v^2 \div 2g$ is the "head" of the current. The coefficient k has been determined by different experimenters to be about 1.70 for average wind velocities. The average of the writer's experiments is 1.72. Of course the value of the factor w will vary somewhat with the ordinary thermic and barometric changes and the value of k should increase with the velocity. However, the above approximations are good in ordinary conditions.

When the plane is inclined to the direction of the current like a kite, the previous relations are curiously changed. Both the pressure normal to the plane and its center of application, which was the center of area, vary with the contour or form and the degree of inclination.

[1] In accordance with the policy of publishing the views of those who have written on the theory of the kite, the Editor is permitted to reproduce, herewith, the essay of Mr. Horace M. Decker, whose graduating thesis with experiments on the resistance of the air formed an early contribution to meteorology in its relation to engineering.

To Duchemin is due the following equation for wind pressure on inclined planes:

$$P_n = P_{90} \frac{2 \sin a}{1 + \sin^2 a}$$

P_n is the resultant pressure normal to the plane, while P_{90} is the pressure on the plane, when at right angles to the current, as given by equation (1); a is the inclination of wind to the surface of the plane.

Duchemin's determination gives results closely confirmed for a square plane by experiments made in London by Wenham for the English Aeronautical Society and by those of S. P. Langley. The first and last results are presented by the curves of Fig. 1, Chart VI. The influence of the form of the plane is shown by the curves of relative pressures in Fig. 2, as determined by Langley, for plates of the same area but different proportions.

In making kites the square or approximations thereto are more common and with these forms the pressure will follow closely enough the law of Duchemin. A curve of the values of Duchemin's factor for the normal pressure is given in Fig. 3, as also curves for the ratio of the horizontal and vertical components $P_{\prime}$ and $P_{\prime\prime}$ respectively. Fig. 4 shows the position of center of pressure d/l with varying degrees of inclination for a square plane as determined by different experimenters, where d is the distance between the center of area and center of pressure for varying angles of inclination and l is the length of the side of the square plane. Where the form is other than rectangular, special figuring by areas must determine the approximate values of d.

In the kite we find a static couple about the center of pressure and stable equilibrium because the center of gravity of the plane is carried below the center of pressure either by the form or by the addition of ballast.

In Fig. 5, let P_n be the normal pressure, $P_{\prime}$, $P_{\prime\prime}$ are its components, s is the string, $S_{\prime}$, $S_{\prime\prime}$ are the components of its tension, W represents the total weight of the plane and its ballast acting from the center of gravity (w). Supposing the interbalance of forces to be complete and the plane in stable, uniform flight, then

$$Wd = S_{\prime\prime}\,d_{\prime} \tag{2}$$

$$S_{\prime} = P_{\prime} \tag{3}$$

$$W + S_{\prime\prime} = P_{\prime\prime} \tag{4}$$

and approximately the line tension

$$S = \sqrt{P_{\prime}^2 + (P_{\prime\prime} - W)^2} \tag{5}$$

The center of gravity of the plane is usually near its center of area. With ballast the center of gravity will be lowered by the distance x,

$$x = l\frac{W_{\prime\prime}}{W_{\prime} + W_{\prime\prime}} \tag{6}$$

Where $W_{\prime}$ is weight of plane and $W_{\prime\prime}$, the weight of ballast, l, being the distance between the centers of gravity. But as the tail will be blown back at an angle t with the vertical and partly supported by wind pressure, therefore

$$W_{\prime\prime} = W_t - P_t \sin t.$$

where P_t is the pressure normal to the tail. The relation

$$\sqrt{W_t^2 + (W_t \sin t)^2} > P_t$$

must exist if the tail is to have much effect on the plane at ballast. If the wind pressure does overcome the weight of the tail, the kite will begin to fall spinning, and then ballass presenting less cross section must be chosen.

It is evident that the line tension S is measured by the deflections due to wind pressure and the weight of the cord. The value of the components of these forces may be determined (by an impracticable equation), but it is enough to say that with a continued paying out of line, the kite will rise, with an ever increasing deflection in the cord and decreasing angle of flight, to a certain point of maximum altitude beyond which more line will sag to the earth. This is where the components of the weight and wind pressure due to the line, with maximum deflection, are in excess of $S_{,,}$ as given by equation (5).

Practical trial will determine the characteristics of a type in a short time, where mathematics would be unavailing. Many points treated here generally can be specifically determined by comparison only.

The kite which exposes the greatest area for a given weight of plane, ballast, and cord will have the most carrying capacity. The area of plane divided by the weight of plane will be some measure of the efficiency. But the form of plane and method of suspension are also of importance as influencing the angle of flight and steadiness.

In Eddy's design, a diamond-shaped kite of equal dimensions, the frame crossing at four-fifths the height of the upright, we have provision made, by convexing the frame and bagging the covering, for obtaining sufficient metacentric height without ballast in the form of tail or steadying fins.

The statics of kite are analogous to those of a ship. The vertical distance of the centers of pressure and weight might be called the metacentric height.

Eddy's kite, besides its motor efficiency, has other advantages. The form, triangular, with the base uppermost, gives small range to the center of pressure, therefore enabling an adjustment for raising conditions to hold well into high angles of flight. And the kite itself is a model of compactness, simplicity, strength, and low cost combined with the efficiency needed in high angle flying.

Multiplane kites, like the cellular Hargrave, are less efficient, because according to Mr. Langley's experiments, two superposed planes must be separated nearly their whole width in the direction of the wind motion to obtain the pressure due to their area, and the weight of the lateral partitions counts to disadvantage. Advantages for this special construction are claimed in the way of steadiness, which is probably due to the inertia of the columns of air flowing through the cells. This kite is not in stable equilibrium, as its natural center of gravity is above the centre of pressure of the lower planes which do most of the work.

The little Japanese bird kite will fly fairly well without ballast. The baggy form and flexibility of its wings carry the center of pressure above the center of gravity. But the angle of flight is low owing to the inefficiency of the surface. It is probable that this kite also realizes a steadying influence from the action of the currents of air, in the wing vents. All kites, especially the plane forms, are subject to considerable oscillation while in action, and in the aeroplane ship, where this vibration would be a factor, this idea of utilizing the inertia of air columns may be of advantage.

A kite may rise with the string fastened direct to the framework above the center of pressure, but the use of two or more conductors joining the frame with the line distributes the strains, insures steadiness, and gives self-adjustment in a degree. Call a point on the plane of the kite opposite to this connection, and in a line with the string, the center of suspension. The kite may rise, but if the center of suspension is too high, or if $S_{,,}\ d_{,} > w\ d$ at any angle of flight or ordinary position of plane, the kite will pull over, flounce, and fall. On the other hand, if the center of suspension be too low, or approach too near the center of pressure in any condition, the kite will rear or surge up and dive. These conditions may often be brought about by the wind itself. Air, because of its compressibility, is seldom a steady stream in motion, but consists of waves or impulses of varying velocity and direction, thereby producing glancing or darting in the kite.

In a well-designed kite there are rather wide limits for the position of the center of suspension within which a change only influences the angle of flight in a degree. That is, the kite with a given adjustment of connection, within these limits, will go safely and self-regulating through wide angles of inclination and flight. The length of the conductors or the distance of the point of suspension from the plane is also an important adjustment, since the amount of change in the position of the center of suspension subtended by a given change of angle of inclination is dependent on this length, and lack of adjustment in this particular will limit the angle of flight.

In general, the forces in action will vary with the square of the wind velocity, and the tension at the point of observation will decrease, for a given wind velocity and length of line, more or less closely with the cosine of the angle of flight. The bird, the prototype of the kite, presents many perfect analogies. In sailing flight the component $P_{,,}$ of the air pressure on its wings is balanced by the action of gravity, while $P_{,}$ represents the de-accelerating force on its mass, or the resistance to motion. The weight of the bird is comparable to the weight of the kite W, plus the vertical component of the line tension $S_{,,}$. And $S_{,}$ may be compared to the momentum, or, at times, the relative inertia of the bird. Again, the great disproportionate spread of wing to breadth in the best sailers is a natural proof of the law involved in the curves of Fig. 2.

HIGHS AND LOWS.

By N. R. TAYLOR, Observer, Weather Bureau (dated September 21, 1897).

Those who make a study of the weather maps issued by the United States Weather Bureau will doubtless read this article with at least passing interest. Although it is not an easy matter to write intelligently upon a scientific subject without scientific words creeping in, yet it is the intention to make this article plain without imperiling the subject, and to avoid all terms that would tend to confuse.

Besides the lines representing barometric pressure in inches and temperature in degrees, the maps contain the words "High" and "Low," every map showing at least one of each. These highs and lows are the most conspicuous features on the maps, and, it might be added, the least understood by the casual observer.

A whole chapter could be written upon the weather conditions represented by the lines, or curves, inclosing high and low areas, but this paper will suffice to give the reader a general idea of their importance in forecasting the weather.

As the words high and low imply, one is the opposite of the other, and they are used on the weather maps to designate the centers of those areas over which a relatively high or low reading of the barometer is observed. These areas of pressure are inclosed by isobaric lines, and include that part of the country over which the pressure is highest or lowest, as the case may be, when compared with other sections, and their centers are located where the greatest or least barometer reading has been observed. It will be seen that the words "High" and "Low" are comparative terms, hence when a high or low pressure is noted on the border of the territory covered by the weather maps, their areas are not sufficiently defined to admit of their centers being accurately located, in which case the highest or lowest pressure observed is quoted, and the isobars are then in the form of short curves.

The lines running through places of equal pressure, showing the different barometric heights, are aptly illustrated by the contour lines employed by civil engineers to mark the relative altitudes of various points.

A glance at a few characteristics of highs and lows and

Chart VI. Diagrams to accompany "The Mechanism of the Kite," by Mr. Decker.

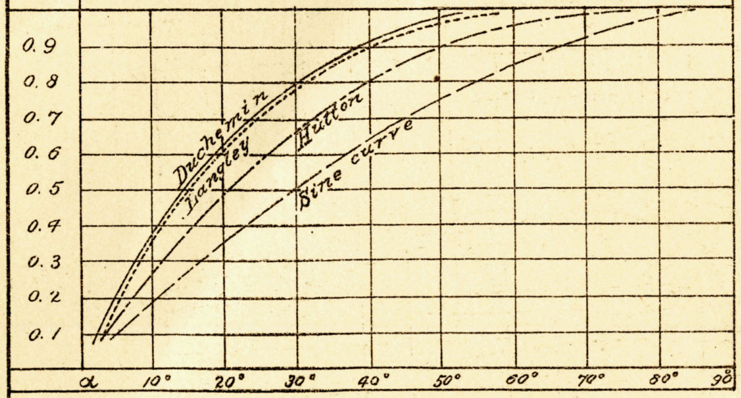

Fig. 1.—Relative total pressures normal to inclined square plates, as obtained by different observers.

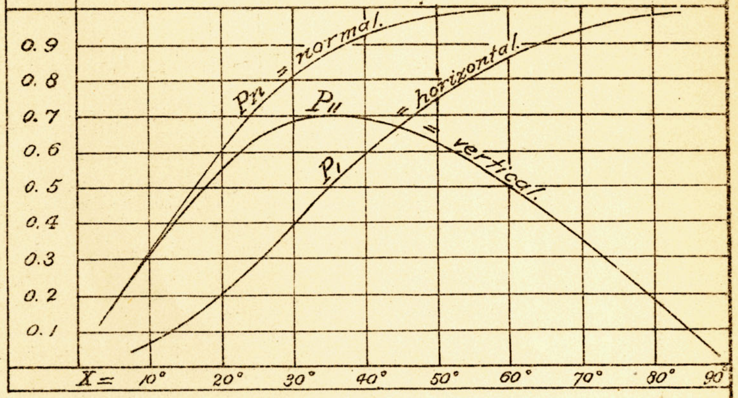

Fig. 3.—Curves representing Duchemin's factor P_n and the component pressures $P_{/} = P_n \sin a$ and $P_{//} = P_n \cos a$.

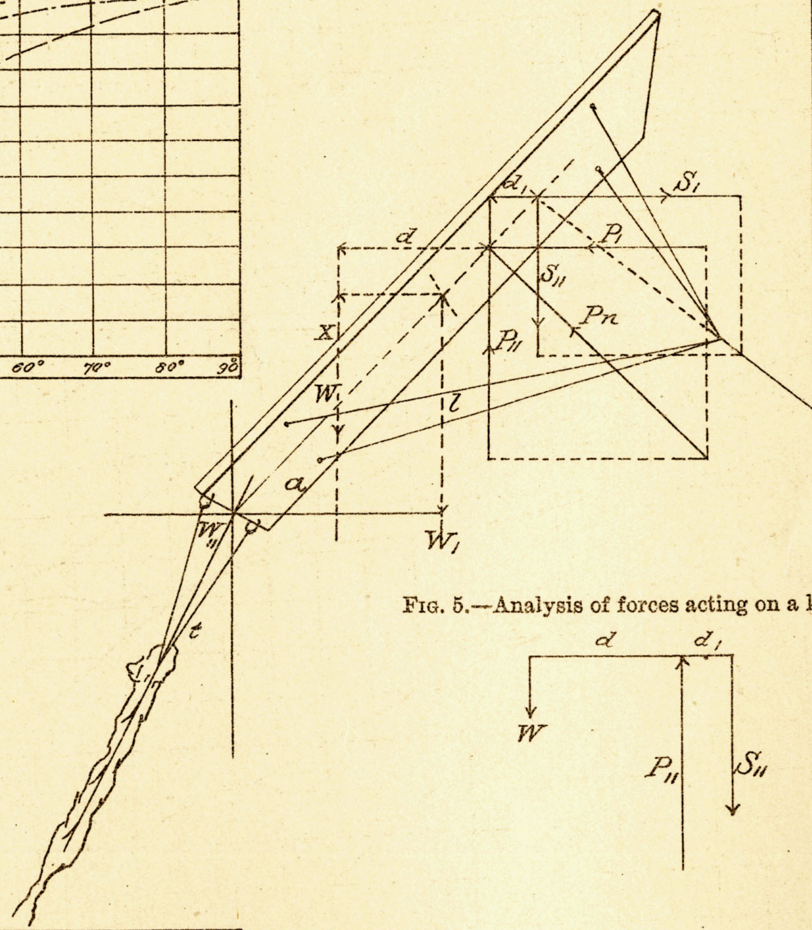

Fig. 5.—Analysis of forces acting on a kite.

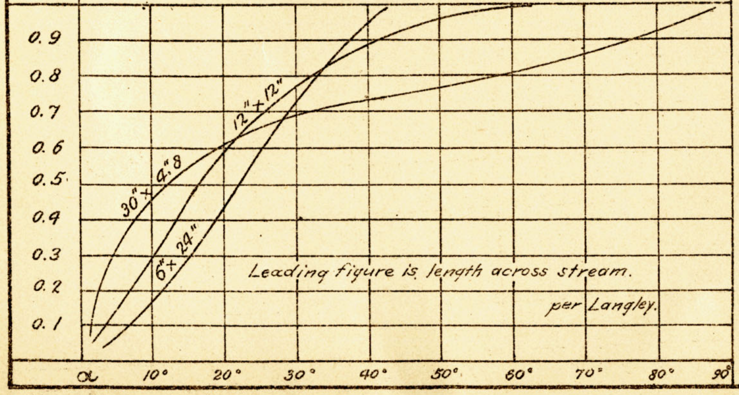

Fig. 2.—Relative total pressures normal to inclined rectangular plates, all having the same areas but different proportions. From Langley.

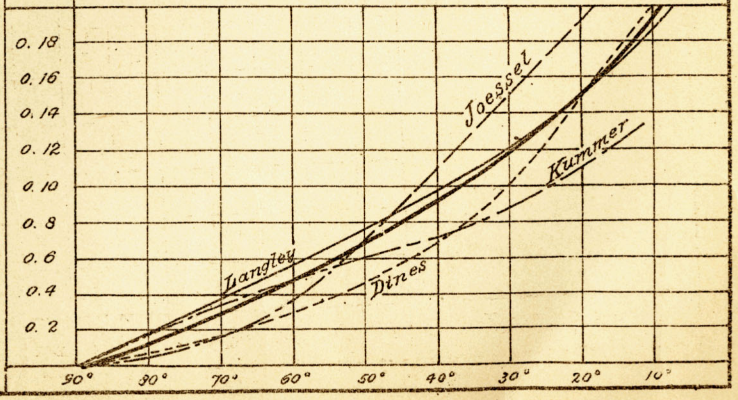

Fig. 4.—Curves showing d/l or the relative distance d of the center of pressure in front of the center of area for squares whose side is l.